

<p align="center">LLNL Environmental Restoration Division Standard Operating Procedure</p>	<p align="center">TITLE: Developing Ground Water Monitoring Sampling Schedules</p>
<p>APPROVAL _____ Date _____</p> <p>Environmental Chemistry and Biology Group Leader</p>	<p align="center">PREPARERS: V. Dibley, R. Goodrich, S. Hassan, G. Howard, and G. Kumamoto</p> <p align="center">REVIEWERS: R. Brown*, T. Carlsen, E. Christofferson*, B. Failor*, J. Duarte, F. Hoffman, B. Hoppes*, V. Johnson, D. MacQueen*, P. Ottesen, B. Qualheim, M. Ridley, and B. Ward*</p>
<p>APPROVAL _____ Date _____</p> <p>Division Leader</p> <p>CONCURRENCE _____ Date _____</p> <p>QA Implementation Coordinator</p>	<p align="center">PROCEDURE NUMBER: ERD SOP-2.11</p> <p align="center">REVISION: 0</p> <p align="center">EFFECTIVE DATE: December 1, 1995</p> <p align="center">Page 1 of 23</p>

*Operations and Regulatory Affairs Division

1.0 PURPOSE

To describe a method for developing schedules for sampling the Environmental Protection Department's (EPD) monitor wells. The main objectives of the sampling schedules are two fold: 1) to assure adequate monitoring of ground water contamination, and 2) to perform sampling in a cost effective manner. This SOP includes procedures for developing and maintaining sampling schedules for both the Livermore Site and Site 300, as well as how the sampling schedules received from the Operations and Regulatory Affairs Division, Water Guidance and Monitoring Group (ORAD/WGMG) are incorporated into the ERD Sampling Plans.

2.0 APPLICABILITY

This procedure is applicable to setting schedules and writing sampling plans for ground water samples collected at Site 300 and the Livermore Site from monitor wells and piezometers (both present and future) for the Environmental Restoration Division. This procedure is not applicable to the development of sampling plans for ORAD/WGMG. However, it is applicable to how the sampling plans developed by the ORAD/WGMG analyst are turned over to ERD and their treatment thereafter by ERD. This procedure is not applicable to the self-monitoring sampling schedule requirements described in the California Regional Water Quality Control Board (CRWQCB) Waste Discharge Requirements (WDR) for Treatment Facility A (WDR Order #88-075), Treatment Facilities B, C, D, E, and F (WDR Order #91-091), the Eastern General Services

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Area (GSA) Treatment Facility (WDR Order #91-052), or the Central GSA or Building 834 Treatment Facility Substantive Requirements.

3.0 REFERENCES

- 3.1 Lawrence Livermore National Laboratory, Remedial Design Report No. 1 for treatment Facilities A and B, April 12, 1993.
- 3.2 Lawrence Livermore National Laboratory, Remedial Design Report No. 2 for Treatment Facilities C and F, September 10, 1993.
- 3.3 Lawrence Livermore National Laboratory, Remedial Design Report No. 3 for Treatment Facilities D and E, September 30, 1993.
- 3.4 W. A. McConachie Memo, RE: Sampling Schedule for the LLNL Livermore Site Wells, February 10, 1993.
- 3.5 A. Lamarre, and R. Powell Memo, Routine Monitor Well and Spring Sample Frequency/Analyte List, LLNL Site 300, January 6, 1994.
- 3.6 California Regional Water Quality Control Board (CRWQCB), San Francisco Bay Region, Order No. 91-091, NPDES NO. CA0029289.
- 3.7 California Regional Water Quality Control Board (CRWQCB), San Francisco Bay Region, Order No. 88-075.
- 3.8 California Regional Water Quality Control Board (CRWQCB), Central Valley Region, Order No. 91-052, NPDES NO. CA0082651.
- 3.9 California Regional Water Quality Control Board (CRWQCB), Central Valley Region, Substantive Requirements, Central GSA Removal action, Lawrence Livermore National Laboratory Site 300, San Joaquin County, December 17, 1993.
- 3.10 Lawrence Livermore National Laboratory, Record of Decision for the Lawrence Livermore National Laboratory Livermore Site, July 15, 1992.

4.0 DEFINITIONS

4.1 Cost-Effective Sampling Algorithm (CES Algorithm or Algorithm)

A methodology with supporting software, for estimating an appropriate frequency (and, as a result, lowest cost) of a sampling schedule for a given ground water monitoring location and still provide needed information for remedial and compliance-related decision making. The CES Algorithm bases sampling frequency decisions on quantitative analyses of the trends and variability of important contaminants (e.g., volatile organic compounds) at a given monitoring location. Refer to Attachment A through E for the Algorithm explanation and flow charts.

4.2 EPDDATA

A relational database used by ERD for the storage and retrieval of data generated in environmental sampling, analysis, measurement, characterization, and remediation activities.

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4.3 SPACT (Sampling Plan and Chain-of-Custody [CoC] Tracking)

A set of data tables in the relational database EPDDATA used by ERD for storage and retrieval of data generated in sampling plan and Chain-of-Custody (CoC) tracking activities.

5.0 RESPONSIBILITIES

5.1 Data Management Group (DMG)

The DMG, in affiliation with the Sampling Coordinator (SC), maintains an electronic record of the sampling plan, its implementation, and the receipt of resulting analytical data. The DMG runs the Algorithm at the request of the SC. The DMG provides, upon request, reports of the sampling plan, the status of particular planned or collected samples, and the status and/or content of resulting analytical data. Furthermore, the DMG supports the Facility Task Leader (FTL)/Study Area Leader (SAL), SC, and field technicians by supplying clarification of sample identification and requested analysis codes used on CoC forms, as well as assistance in analyzing and trending sampling results upon request.

5.2 Division Leader

The Division Leader's responsibility is to ensure that all activities performed by ERD at the Livermore Site and Site 300 are performed safely and comply with all pertinent regulations and procedures, and provide the necessary equipment and resources to accomplish the tasks described in this procedure.

5.3 Environmental Chemistry and Biology Group Leader (ECBGL)

The ECBGL's responsibility is to assist the FTL/SAL in reviewing the sampling plans and determining sampling frequency. The ECBGL may also assist the FTL/SAL in tracking, analyzing, and trending the sample results.

5.4 ERD Livermore and Site 300 and ORAD Environmental Monitoring Program Leader (or Designee)

The Program Leader's (or Designee's) responsibilities are to assure the proper implementation of DOE and regulatory requirements and all applicable procedures. The Program Leader also provides the policy (including program objectives), tools and resources, training and support necessary to enable the Program to perform in an efficient and timely manner.

5.5 Facility Task Leader (FTL)—Livermore Site

The FTL's responsibility is to track, analyze, and trend the sampling results of each well associated with the ground water treatment facility. The FTL can request the SC to run the Algorithm as needed, instructs the SC to revise the frequency of the sampling schedule, and adds (or deletes) sampling wells to the facility list based on the Algorithm results and the special needs of the facility.

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5.6 Operations and Regulatory Affairs Division (ORAD)/Water Guidance and Monitoring Group (WGMG) Analyst

The ORAD/WGMG analysts responsibilities are to provide the appropriate SC with their sampling requirements one month before the quarter begins for inclusion into the sampling plan. The ORAD analyst will review the final sampling plan and inform the SC of any errors one week before the quarter begins. During the course of the quarter, the ORAD/WGMG analyst will inform the SC, QC chemist, DMG, or ECBGL as appropriate, of any problems they encounter. The ORAD/WGMG analysts will also be responsible for compliance with non-CERCLA laws and regulations including RCRA, RWQCB orders, and DOE orders.

5.7 QC Chemist

The QC Chemist provides technical support and assists the FTL/SAL/Analyst, scientist or engineer in evaluating and assessing the analytical data resulting from implementation of the quarterly sampling plan. Furthermore, the QC Chemist supports the SC by supplying clarification and counsel on sample analysis and QC requirements.

5.8 Sampling Coordinator (SC)

The SC, in affiliation with the DMG, maintains the sample planning portion of SPACT tables within the EPDDATA database. The SC will request the Algorithm to be run as required or when requested by the FTL/SAL. In collaboration with the QC Chemist, the SC advises the FTL/SAL of the results of the Algorithm, and the available options to formulate a new sampling schedule. In addition, the SC ensures the sampling schedule and instructions of the FTL/SAL/Analyst are properly executed.

5.9 Study Area Leader (SAL)—Site 300

The individual SAL's responsibility is to track, analyze, and trend the sampling results of each well associated with his/her study area. The SAL instructs the SC to revise the frequency of the sampling schedule, and add (or delete) sampling wells to the sampling plan.

6.0 PROCEDURES

6.1 Discussion

The sampling frequency for most wells at Site 300 and the Livermore Site is either annually, semiannually or quarterly. Site 300 water supply wells and strategically located offsite domestic wells are sampled monthly. This SOP outlines the procedure that ERD uses to determine monitor well sampling frequency. The Livermore Site monitor well sampling frequency is specific of guidelines (termed the "Algorithm") based on the contaminant concentration history of each well, relationship to concentration of the contaminant plume, and input from the FTL. At Site 300, the ERD monitor well sampling frequency is based on a set of criteria developed by the SAL in conjunction with the QC Chemist, ECBGL, SC, and other key staff members. Work on developing an Algorithm for Site 300 is underway. In addition to the wells ERD samples for the restoration projects, ERD also samples wells at the Livermore Site and Site 300 for the Environmental Monitoring Program (EMP). The ORAD/WGMG analysts determine the sampling schedules of the EMP wells and supply the appropriate ERD SC with the schedule.

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6.2 Livermore Site Determination of Sampling Schedules for ERD Wells

- 6.2.1 The sampling schedules are evaluated quarterly to monitor the changes in the concentration of the contaminants in ground water. The sampling frequency is determined by evaluating the overall and recent history (last 18 months) of each well.
- 6.2.2 The SC requests DMG to run the Algorithm prior to the beginning of each quarter. The SC reviews the results of the Algorithm for each monitor well and piezometer to determine the adequacy of the sampling frequency.
- 6.2.3 The main features of the Algorithm that determine the sampling frequencies are the following decision criteria:
- Wells exhibiting little change (<10 ppb/y) will be sampled annually.
 - Wells exhibiting moderate change (10 ppb but <30 ppb/y) will be sampled semiannually.
 - Wells showing large change (30 ppb) will be sampled quarterly.
 - Wells with less than 18 months of analytical history will be sampled quarterly for the first 18 months, then the flow chart logic takes over to determine the sampling frequency.

The results of the concentration change analysis are also considered in light of the variation within the analytical data.

- 6.2.4 The SC discusses the algorithm results with the FTL and the QC Chemist to arrive at a revised sampling frequency schedule. The agreed upon schedule is then recorded electronically in the SPACT tables of the EPDDATA database. The SC coordinates with the DMG to accomplish timely electronic recording.
- 6.2.5 If the sampling schedule is to be revised, it is the responsibility of the FTL to inform the SC in writing about the change(s) in the sampling schedule. Recommendations of the Algorithm output is used to approve the new quarterly sampling plan. Should changes be necessary during the quarter, The Request for Sampling Schedule form (Attachment G) should be used to communicate the change.
- 6.2.6 The SC must acknowledge in writing, via either the form, receiving the revised sampling instructions by filling out the bottom portion of the form. When completed, the SC sends a copy of the form to the FTL. The original form becomes a QA record and is sent by the SC to the ERD Document Control Center.
- 6.2.7 Each Request for Sampling Schedule Change resulting in a change to the previously electronically recorded sampling schedule will require an update of the SPACT tables of the EPDDATA database. The SC will coordinate with the DMG to achieve a timely update.
- 6.2.8 The finalized sampling plan is made available to the FTL/Analyst for final review prior to the start of sampling activities. The FTL/Analyst informs the SC of any errors. Corrections are made, and the sampling plan reissued.
- 6.2.9 The FTL has the option of adopting a sampling plan that is not in agreement with the decisions provided by the Algorithm based upon best professional judgment.
- 6.2.10 Wells located downgradient of the contaminant plume, west and south of LLNL, will remain on a quarterly sampling schedule to monitor for plume breakthrough. Ground water extraction wells associated with LLNL treatment facilities will also

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remain on a quarterly sampling schedule to estimate mass removal rates. The samples should be collected at the extraction wellhead.

- 6.2.11 Treatment Facility F (TFF) is not presently included in the schedule revision process due to ongoing investigations in this area. However, when the operation stabilizes, the TFF FTL may elect to use the Algorithm to provide alternative sampling schedule for all or some of the existing monitor wells and piezometers.
- 6.2.12 The analytes to be sampled and the role of response actions are summarized in the Record of Decision (ROD), Reference 3.10. Table 1 of the ROD, "Remediation standards and State discharge limits for compounds of concern in ground water at LLNL site" summarizes the volatile organic compounds (VOCs), fuel hydrocarbons (FHCs), metals, and tritium that are incorporated in the ground water sampling program. The analytes to be sampled at a particular location or well are determined by the FTL in conjunction with the QC Chemist and SC.

6.3 Site 300 Determination of Sampling Schedules for ERD Wells

- 6.3.1 Ground water samples are collected from existing monitor wells which are installed within defined study areas. Site 300 is currently divided into six study areas consisting of Building 833, Building 834, EWFA (East and West Firing Areas), PIT6, HE (High Explosives) Process Area, and GSA (General Services Area).
- 6.3.2 A set of criteria developed by the SAL, QC Chemist, ECBGL, SC, and other key staff members provide guidelines to determine the sample frequency of ground water monitor wells. The criteria established are as follows (see flow chart in Attachment G):
- Annually Sampled Wells—Wells that have not detected contaminants of concern for at least 1 year or have stable contaminants concentrations and are in a non-critical local.
 - Semi-annually Sampled Wells—Wells with slow moving plumes and/or in a non-critical local (i.e., upgradient of source).
 - Quarterly Sampled Wells—Wells with fast moving plumes and/or critical local (i.e., leading edge of plume or guard well).
 - Monthly Sampled Wells—Water-supply wells and off-site domestic wells.
- 6.3.3 The sampling schedule is compiled on a quarterly basis from templates housed within the SPACT tables of the EPDDATA database. The templates store information pertinent to the successful sampling of monitoring wells and serve as a starting point. The sampling schedule is evaluated quarterly as the contaminant concentrations in ground water change and/or new monitoring wells are installed.
- 6.3.4 The SC distributes the quarterly sampling plan to SALs, ECBGL, and the QC Chemist to generate recommendations to the sampling plan. The SAL submits changes to the SC who coordinates with the DMG to achieve a timely update to the SPACT tables.
- 6.3.5 If the sampling schedule is to be revised, it is the responsibility of the SAL or Analyst to inform the SC in writing about the changes in the sampling schedule. Attachment F shows the Request for Sampling Schedule Change form to be used to communicate the changes.

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- 6.3.6 The SC must acknowledge in writing, via the form, receiving the revised sampling instructions by filling out the bottom portion of the form. When completed, the SC sends a copy of the form to the SAL. The original form becomes a QA record and is sent by the SC to the ERD Document Control Center.
- 6.3.7 Each Request for Sampling Schedule Change resulting in a modification to the previously electronically recorded sampling schedule will require an update of the SPACT database. The SC will coordinate with the DMG to facilitate the update to the SPACT tables.
- 6.3.8 The finalized sampling plan is made available to the SAL for final review prior to the start of sampling activities. The SAL informs the SC of any errors, corrections are made, and the sampling plan reissued.
- 6.3.9 Ground water extraction wells associated with Site 300 treatment facilities will remain on a quarterly sampling schedule. The SAL may have to modify existing ground water sampling methods to suit the specific need of the treatment facility. SOPs defining distinct sampling protocol will be developed for each treatment facility as needed.
- 6.3.10 The sample frequency and the required analyses for monitor wells associated with the treatment facilities at Site 300 are determined within the scope of the NPDES permit (Reference 3.8). The monitoring of the Site 300 treatment facility(s) is declared within the guidelines established within the NPDES permit and is not modified otherwise.
- 6.3.11 The analytes to be sampled at a particular location or well are determined by SALs in conjunction with the ECBGL, QC Chemist and SC. This determination is based on the results from numerous investigative methods and techniques utilized to identify areas where chemicals may have been used, stored, and/or disposed. Through investigations in these suspect areas, contaminants of concern are identified and added to the sampling plan. Analytes may also be added to the sampling plan in response to specific regulatory agency requests. See Attachment G for a flow chart of the decision process.
- 6.3.13 As isoconcentration and water elevation contour maps are prepared, the location of the well and its relationship to the plume is reevaluated. The sampling frequency may or may not change according to the reevaluation.

6.4 Handling of ORAD/WGMG Sampling Schedules

6.4.1 Livermore Site

Concurrent with and independent of the Algorithm run, the Livermore Site SC receives written instructions of sampling requirements from the ORAD/WGMG analyst for the upcoming quarter one month ahead of time. The SC, along with DMG, ensures that the sampling plan is updated, then returns the final plan to the ORAD/WGMG analyst. The analyst will then review the plan and inform the SC of any errors no later than one week before the quarter begins.

6.4.2 Site 300

The ORAD/WGMG analyst will provide the SC with their sampling Plan requirements one month before the quarter begins. The SC will incorporate the EMP's sampling requirements into the ERD sampling plan and redistribute the Plan to the ORAD/WGMG analyst. The analyst will review the Plan and return comments (if any) one week before the quarter begins.

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- 6.4.3 During the coarse of the quarter, the ORAD/WGMG analyst will inform the SC, QC Chemist, DMG, or ECBGL as appropriate, of any problems they encounter.

7.0 QA RECORDS

- 7.1 Request for Sampling Schedule Change Form (Attachment F)
- 7.2 Copy of the Algorithm Recommendations
- 7.3 Copy of the Sampling Plan
- 7.4 Written Instructions from WGMG Analysts

8.0 ATTACHMENTS

- Attachment A—Explanation of Algorithm Flow Chart
- Attachment B—Algorithm Overview
- Attachment C—Cost-Effective Sample Frequency Estimation Step 1
- Attachment D—Cost-Effective Sample Frequency Estimation Step 2
- Attachment E—Cost-Effective Sample Frequency Estimation Step 3
- Attachment F—Request for Sampling Schedule Change form
- Attachment G—Flow Chart of Site 300 Ground Water Sampling Analysis and Frequency

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Attachment A

Explanation of Algorithm Flow Chart

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Principles of Cost-Effective Sampling (CES)

The determination of sampling frequency for a given location is based entirely on trend, variability, and magnitude statistics describing the contaminants at that location. The underlying principle is that a location's schedule should be primarily determined by the rate of change in contaminant concentrations that have been observed in the recent past. The higher the rate of change, whether upward or downward, the greater the need for frequent sampling. Conversely, where little change is observed, a less frequent schedule can be followed. A second rationale for more frequent sampling is the degree of uncertainty displayed in the measured concentrations. Low overall rates of change can be offset by a higher degree of variability, requiring a more frequent schedule to be maintained to better define the likely degree of contamination at that location. Finally, the magnitude of the measured concentrations affects the interpretation that is placed on rates of change. Clearly, a yearly change of 50 parts per billion (ppb) means something quite different when the median concentration is 10 vs. 1000 ppb.

The Flow Charts

To be eligible for consideration, a location (usually a groundwater monitor well) must have been sampled at least six times, which is roughly equivalent to 18 months of quarterly sampling. Newly installed wells must be sampled frequently to build up a history for the purposes of analysis. Although not explicitly shown in the flow chart, it is also understood that some locations will have their schedules determined by regulatory or remedial reasons that have little to do with the types of analyses being considered here. The decision-rules of the system are applied independently to each contaminant in the target list for a particular location. The schedule assigned to the location is the most frequent schedule estimated for any individual contaminant. A brief description of the statistics and logic in each step follows:

Step 1

Set frequency based on recent trends. As was mentioned earlier, the primary focus of CES is on interchange trends or rates of change. This is currently defined as the least-squares slope obtained by regressing measured concentrations against time. The advantage of this statistic is ease of interpretation. The slope can be expressed as a yearly change in concentration. The disadvantage is that suitability for use with non-linear trends is questionable. Part of this problem could be solved by linearizing the data by a means of a natural log transformation. However, this introduces interpretation problems which, for this first simple version of CES, we are trying to avoid.

Step 2

Adjust frequency based on overall trends. While emphasis is placed on setting frequencies from recent data, there are cases where a long-term history of change may override the Step 1 decision. The first three boxes in the Step 2 flow chart weeds out cases where such a reevaluation is undesirable or trivial.

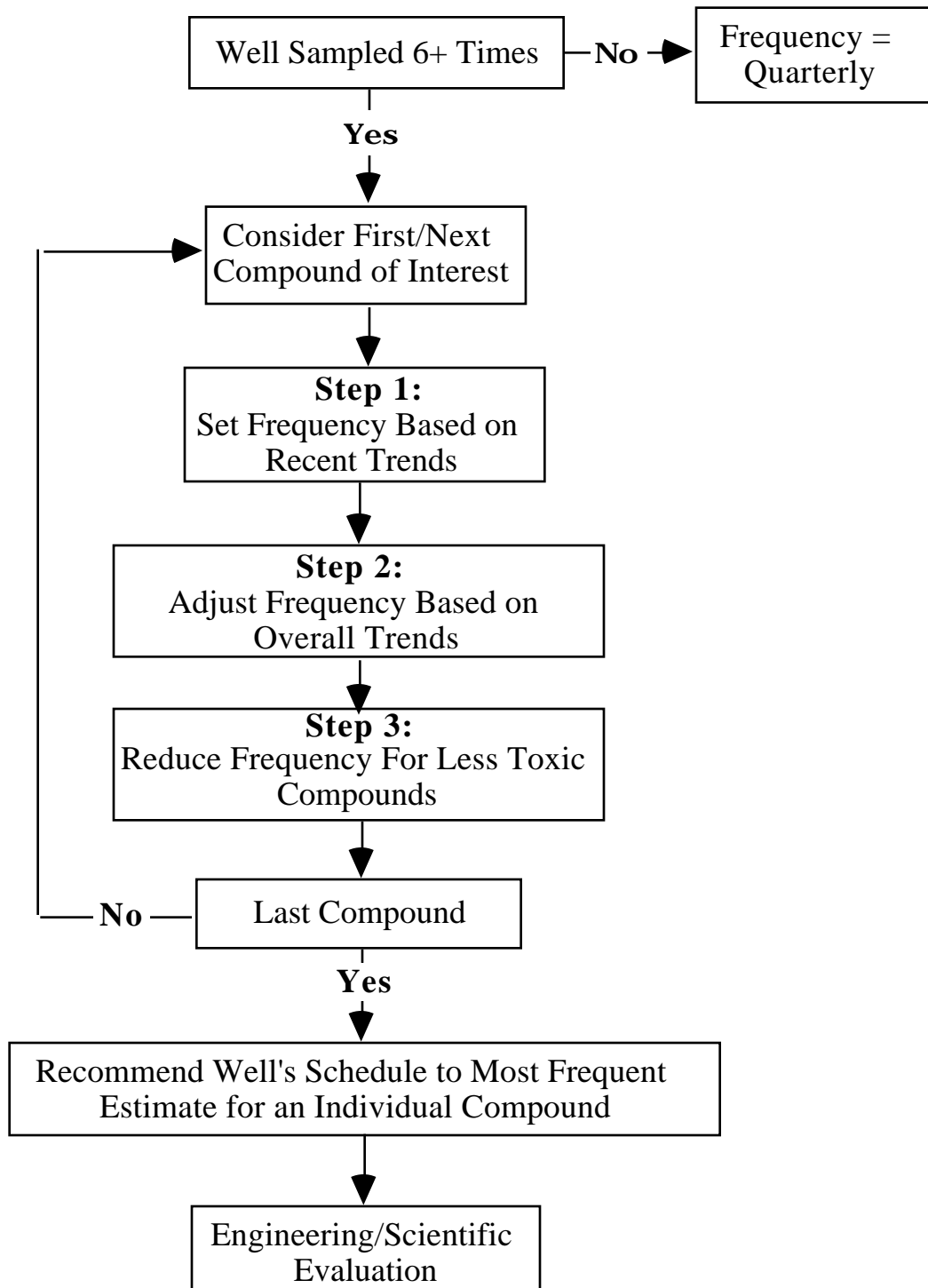
Step 3

Reduce frequency for less toxic compounds. Not all compounds in the target list are equally harmful. Because of differences in drinking water standards, an average trend of 25 ppb/year for TCE is far more serious than the same trend for Chloroform or the two forms of Freon. So, quarterly and semiannual decisions are reduced one level if the maximum concentration in the recent set of samples is less than one half of the maximum permissible contaminant level. It is expected that future versions of CES will tailor all explicit cut-offs in the flow-logic to individual contaminants.

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Attachment B

Algorithm Overview

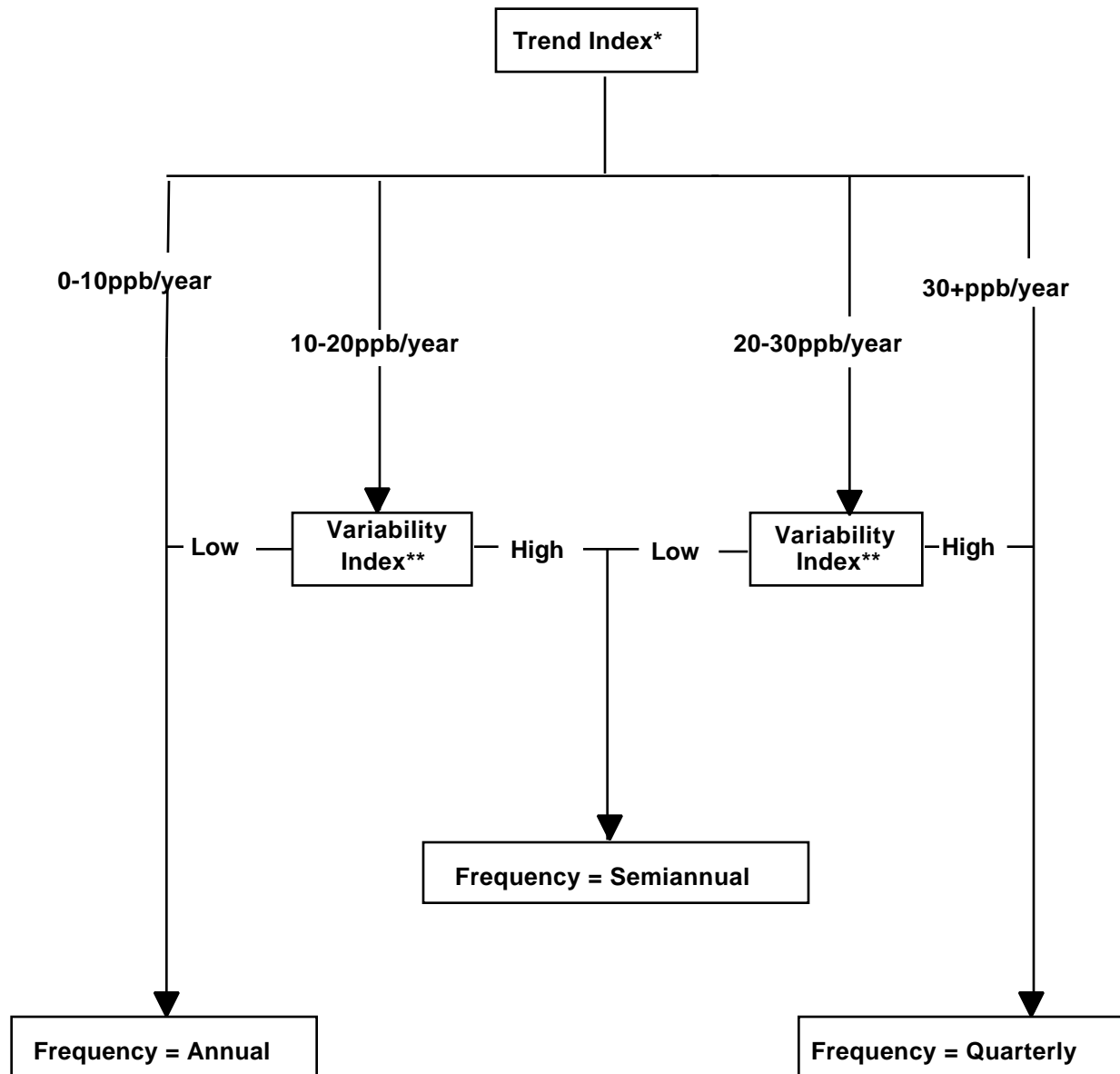


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Attachment C

Cost-Effective Sample Frequency Estimation (Step 1)

Step 1: Set Frequency Based on Recent Trends



* Currently defined as the absolute value of the least-squares slope.

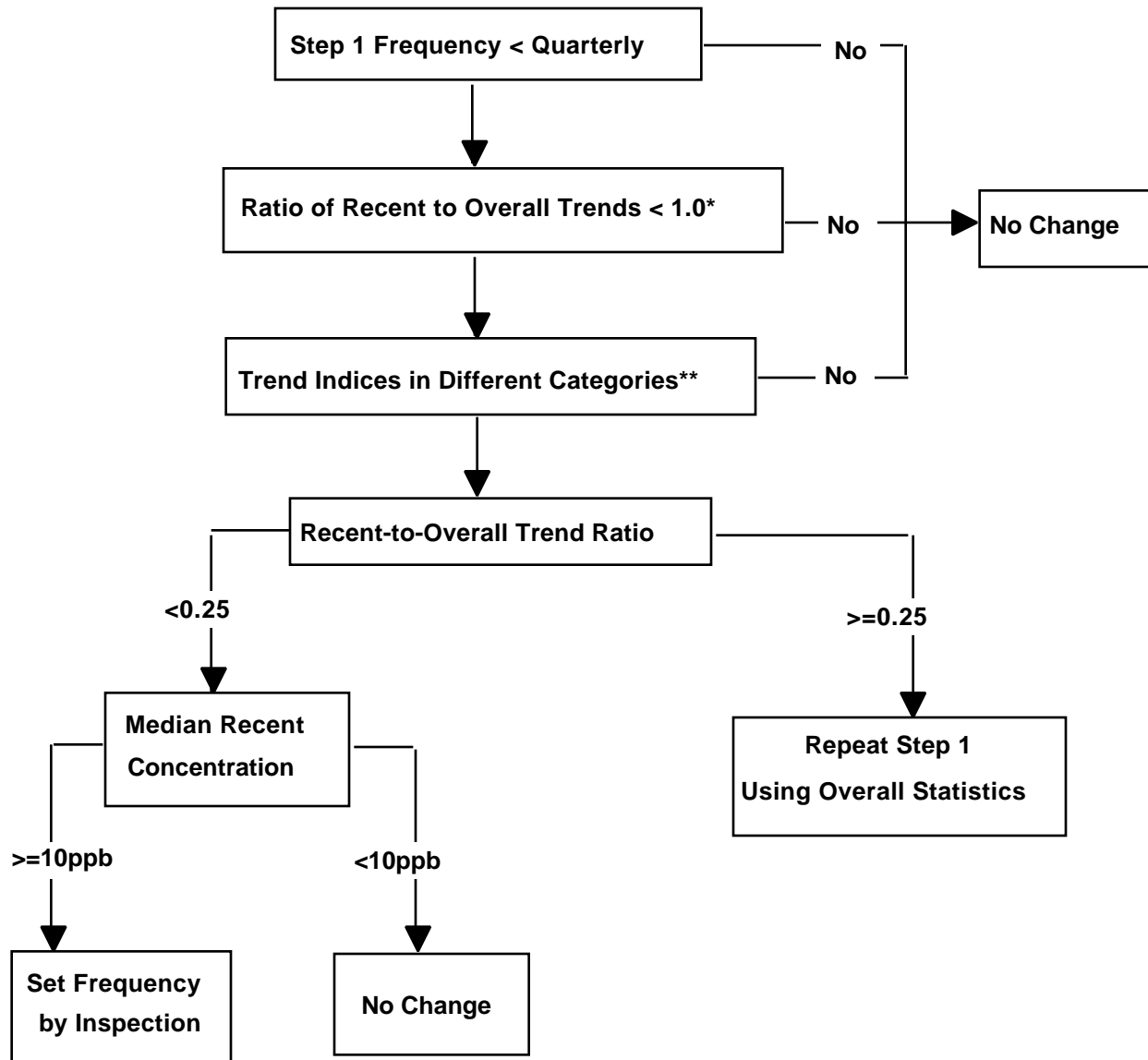
** Currently defined as the range divided by the median concentration, with a high-low break at 1.0.

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Attachment D

Cost-Effective Sample Frequency Estimation (Step 2)

Step 2: Adjust Frequency Based on Overall Trends



* Absolute value of (recent-slope/overall-slope)

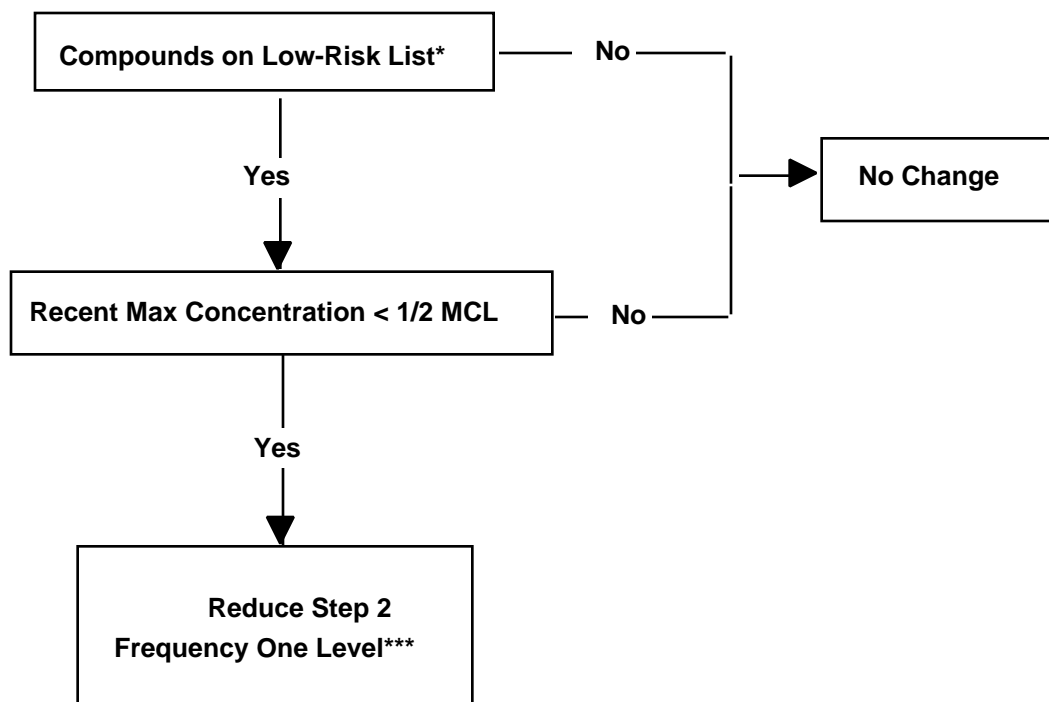
** Refers to the frequency categories: Annual (0-10 ppb/year); Semiannual (10-30 ppb/year); Quarterly (30 + ppb/y)

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Attachment E

Cost-Effective Sample Frequency Estimation (Step 3)

Step 3: Reduce Frequency For Less Toxic Compounds



* Currently chloroform, Freon 11, and Freon 113.

** MCL = maximum contaminant level.

*** Does not apply if Step 2 frequency is "Set by Inspection".

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Attachment F

Request for Sampling Schedule Change

Request for Sampling Schedule Change

To:

Treatment Facility/ OU Area:

From:

Reason for Change:

Please revise the ground water sampling frequency for the following monitoring wells (and/or piezometers) as indicated below. The change is to take effect _____ .

[illegible]

Additional Sheets Attached? _____ No or _____ Yes _____ Additional Pages Attached.

Comments:

Signature _____

Date _____

Acknowledgment

Above revision to ground water sampling schedule for the indicated monitoring wells (and/or piezometers) has been reviewed. Change(s):

_____ will be or _____ will not be implemented as requested.

Comments:

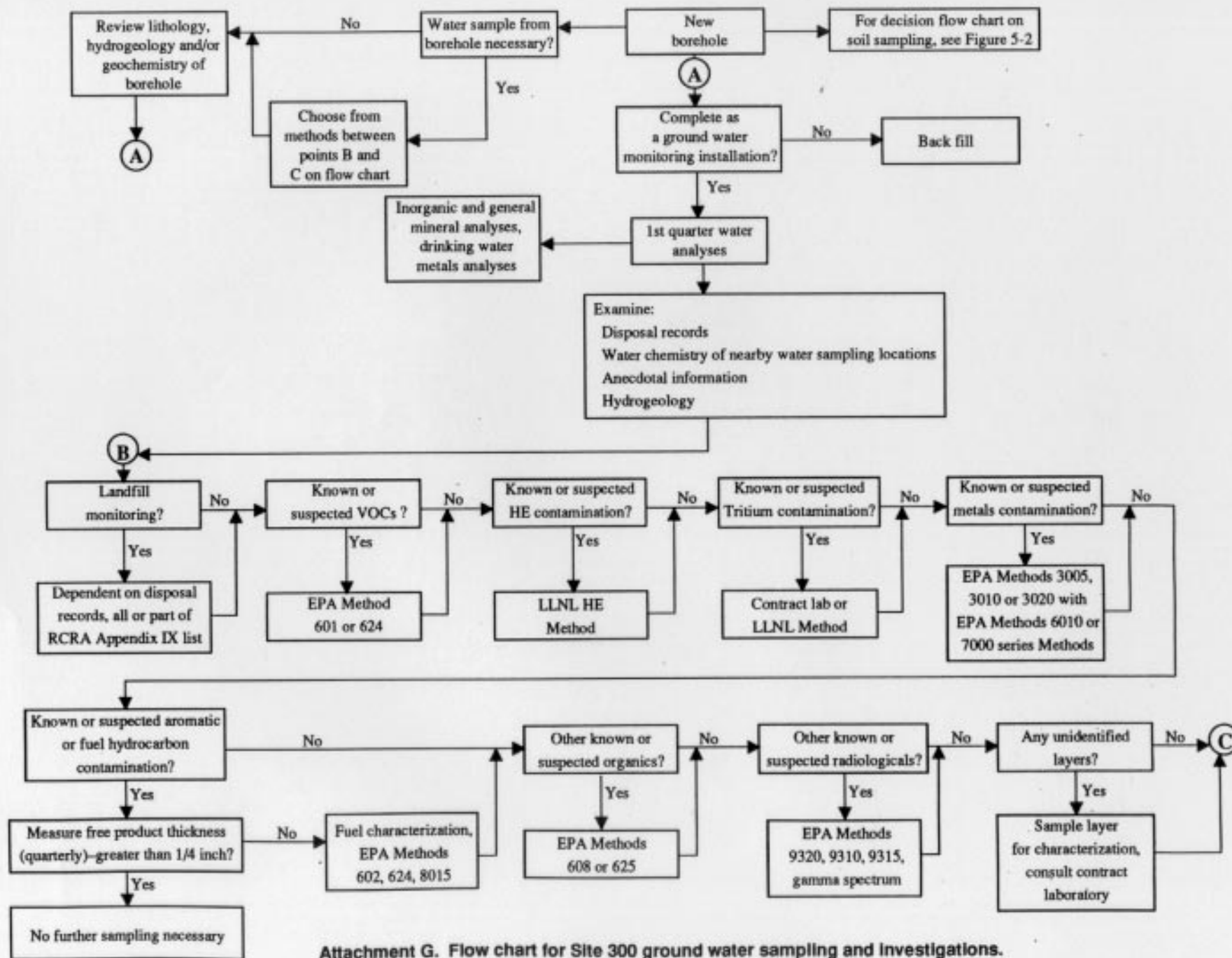
Signature _____

Date _____

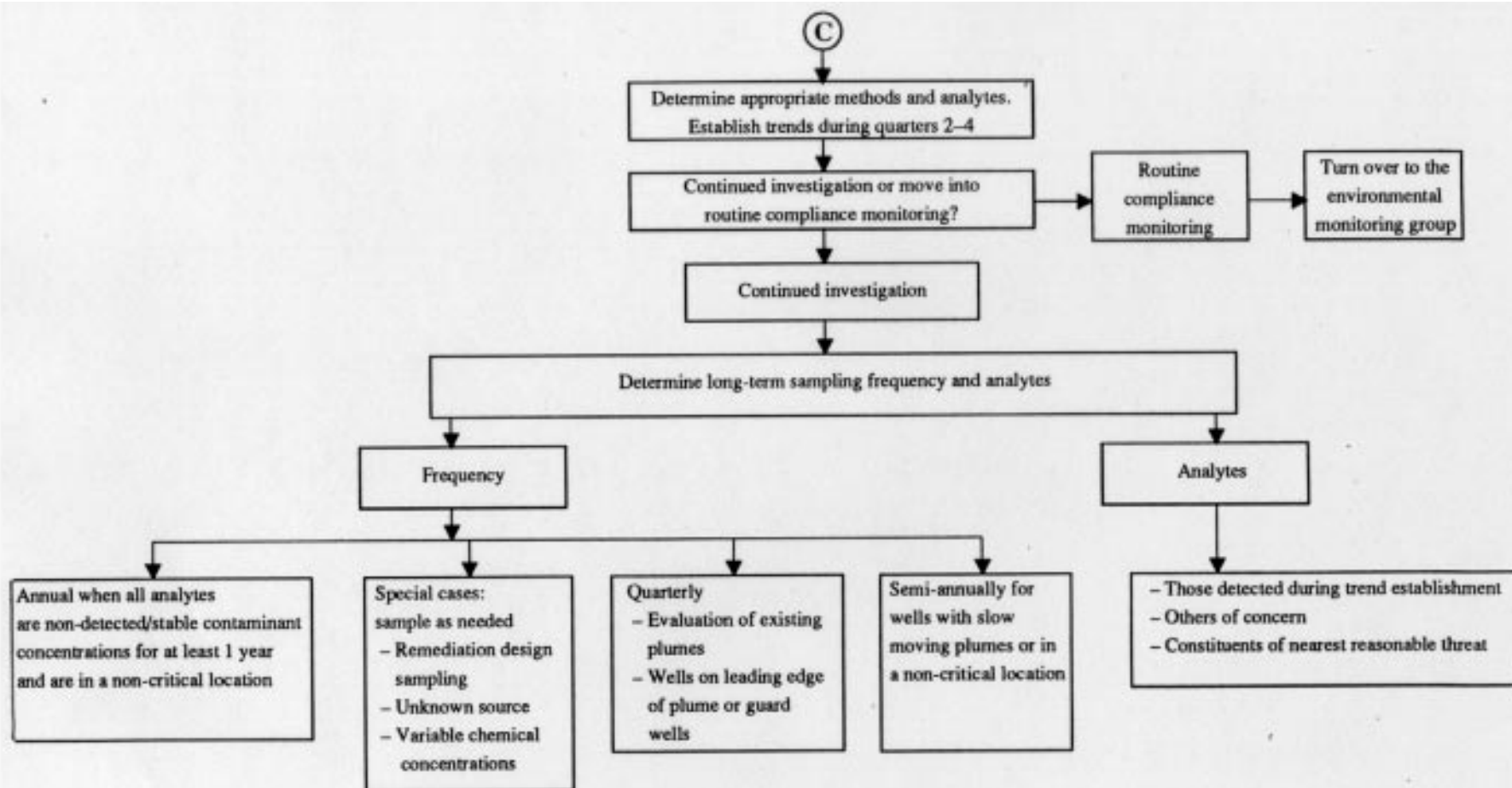
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Attachment G

Flow Chart of Site 300 Ground Water Sampling Analysis and Frequency



Attachment G. Flow chart for Site 300 ground water sampling and investigations.



Attachment G. (continued)